

CLAIMS:

1. A method for producing a silicon single crystal ingot under the following conditions:

(a) V/G value from a crystal center position to a crystal outer periphery position =  $0.16 - 0.18 \text{ mm}^3/\text{°C} \cdot \text{min}$ ,

(b)  $G_{\text{outer}} / G_{\text{center}} \leq 1.10$ , where V (mm/min) is a pulling speed in the Czochralski method, G ( $^{\circ}\text{C}/\text{mm}$ ) is an average value of an in-crystal temperature gradient in a pulling axis direction within a temperature range from a silicon melting point to  $1350^{\circ}\text{C}$ ,  $G_{\text{outer}}$  is a G value on an outer surface of the crystal, and  $G_{\text{center}}$  is a G value at the center of the crystal.

2. The method for producing a silicon single crystal ingot according to Claim 1, characterized in that said conditions (a) and (b) are adjusted by changing a distance between a heat shielding element equipped in a Czochralski method-based silicon single crystal production device and silicon melt.

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3. The method for producing a silicon single crystal ingot according to Claim 1 or Claim 2, characterized in that said conditions (a) and (b) are adjusted by changing the pulling speed of the silicon single crystal ingot when the silicon single crystal ingot is produced by the Czochralski method.

4. A silicon single crystal wafer with decreased grown-in defects, which is obtained from said silicon single crystal ingot according to one of Claims 1 to 3.

5. A silicon perfect single crystal wafer free from grown-in defects, which is obtained from said silicon single crystal ingot according to one of Claims 1 to 3.

6. A method of producing a silicon single crystal ingot, characterized in that the silicon single crystal ingot is produced while adjusting a distance between a heat shielding element equipped in a Czochralski method-based silicon single crystal production device and silicon melt.

7. A Czochralski method-based silicon single crystal production device, comprising, in a closed container, a crucible element which stores silicon melt, rotates and is vertically driven, a pulling element for pulling a silicon single crystal ingot, while rotating, from said silicon melt, a heating element for heating said crucible element and a heat shielding element for shielding radiating heat from said heating element,

characterized in that a drive mechanism for moving said heat shielding element is equipped for changing an in-crystal temperature gradient in a pulling axis direction of the silicon single crystal ingot.

8. A method for obtaining an effect equivalent to changing a pulling speed of a silicon single crystal ingot by a Czochralski method by adjusting a distance between a heat shielding element equipped in a Czochralski method-based silicon single crystal production device and silicon melt.

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9. A heat treating method for a silicon single crystal wafer related to a perfect crystal produced by a Czochralski method, characterized in that a heat treatment temperature at the initial entry of the silicon single crystal wafer to be a target of the heat treatment is 500°C or less, and a temperature ramping rate in a temperature range from the heat treatment temperature at initial entry to an ultimate temperature set in a range of "700°C - 900°C" is set to 1°C/min or less.

10. A heat treating method for a silicon single crystal wafer related to a perfect crystal produced by a Czochralski method, characterized in that a heat treatment temperature at the initial entry of the silicon single crystal wafer to be a target of the heat treatment is 500°C or less, and a temperature ramping rate in a temperature range from the heat treatment temperature at initial entry to an ultimate temperature set in a range of "700°C - 900°C" is set to 1°C/min or less, so as to uniform the distribution of an oxide precipitate density of the silicon single crystal wafer after heat treatment.

11. A heat treating method for a silicon single crystal wafer related to a perfect crystal produced by a Czochralski method, characterized in that a heat treatment temperature at the initial entry of the silicon single crystal wafer to be a target of the heat treatment and a temperature ramping rate from the heat treatment temperature at initial entry to an ultimate temperature set in a range of "700°C - 900°C" are adjusted so as to adjust the distribution of an oxide precipitate density of the silicon single crystal wafer after heat treatment.

12. The method according to Claim 9, characterized in that the oxygen concentration of the perfect crystal is  $13 \times 10^{17}$  atoms/cm<sup>3</sup> or less.

13. A silicon single crystal wafer produced by the method according to Claim 12.

14. A method for controlling a Czochralski method- (hereafter CZ method) based single crystal ingot production device comprising a cooler for cooling a predetermined location of a single crystal ingot being pulled from melt (hereafter single crystal pulling ingot),

characterized in that when a tail of said single crystal pulling ingot is formed, the power consumption of the single crystal ingot production device is decreased by moving said cooler away from the solid-liquid interface between said single crystal ingot and said melt.

15. A method for controlling a Czochralski method- (hereafter CZ method) based single crystal ingot production device where a single crystal ingot is pulled from melt in a heated crucible, said CZ method-based single crystal ingot production device comprising a cooler in a furnace for cooling a predetermined location of a single crystal ingot being pulled,

characterized in that a production time of a single crystal ingot is decreased by moving said cooler and the crucible for which heating is over closer to each other after pulling said single crystal ingot out of said melt.

16. The method according to Claim 15, characterized in that said single crystal ingot is a single crystal ingot which includes a portion of a perfect crystal.

17. A Czochralski method- (hereafter CZ method) based single crystal ingot production device, comprising a cooler, in a furnace, for cooling a predetermined location of a single crystal ingot being pulled from melt in a heated crucible (hereafter single crystal pulling ingot),

characterized in that said cooler is raised to move said cooler away from a solid-liquid interface between said single crystal ingot and said melt when a tail of said single crystal pulling ingot is formed.

18. A Czochralski method- (hereafter CZ method) based single crystal ingot production device comprising a cooler, in a furnace, for cooling a predetermined location of a single crystal ingot being pulled from melt in a heated crucible,

characterized in that said cooler is lowered to cool the crucible for which heating is over after pulling said single crystal ingot out of said melt.

19. The CZ method-based single crystal ingot production device according to Claim 18, characterized in that the cooler is lowered to inside said crucible.

20. A Czochralski method- (hereafter CZ method) based single crystal ingot production device comprising a cooler, in a furnace, for cooling a predetermined location of a single crystal ingot being pulled from melt in a heated crucible,

characterized in that said crucible is raised to cool said crucible by moving said cooler and the crucible for which heating is over closer to each other after pulling said single crystal ingot out of said melt.

21. A Czochralski method- (hereafter CZ method) based single crystal ingot production device comprising a cooler, in a furnace, for cooling a predetermined location of a single crystal ingot being pulled from melt in a heated crucible (hereafter single crystal pulling ingot),

characterized in that, when a tail of said single crystal pulling ingot is formed, said cooler is raised to move said cooler away from a solid-liquid interface between said single crystal ingot and said melt, and said cooler is also lowered to cool the crucible for which heating is over after pulling said single crystal ingot out of said melt.

22. A method for producing a single crystal ingot using a Czochralski method- (hereafter CZ method) based single crystal ingot production device comprising a cooler, in a furnace, for cooling a predetermined location of a single crystal ingot being pulled from melt in a heated crucible (hereafter single crystal pulling ingot), characterized in that a size of a diameter of said single crystal pulling ingot is adjusted by changing a distance of said cooler from a solid-liquid interface between said single crystal ingot and said melt.

*sub A* > 23. The CZ method-based single crystal ingot production device according to one of Claims 17 to 21, characterized in that said single crystal ingot is a single crystal ingot, including a portion of a perfect crystal.